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GB 1205621 GB 0361811
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(54) A process and apparatus for the advancing of band-like conveying means with reduced friction

(57) The underside of band-like transport devices or conveyor belts are placed at least in part on a liquid layer and steps are taken to prevent the carrier surface of the transport device from coming into communicating contact with the liquid layer. In one form of apparatus there is provided a continuous transport belt 1, supporting plates 31 intermittently supporting the belt 1, and a driving device for driving the belt. The supporting plate 31 has a central inlet duct 21 in communicating connection with a source of liquid and its surface is closely adjacent to the underside of the belt 1 so as to form a moving liquid film 11 therebetween. In another apparatus the continuous transport band 1 is concave and is placed on a liquid layer 12 disposed in a liquid reservoir 33. The transport belt may be provided with U-shaped transverse ribs 81 on the carrier surface, the base of the U-shape preferably having bores into which longitudinally extending stiffening members 82 are threaded. In a further alternative the belt is formed from transversely sectioned rubber tyres united at their end faces.

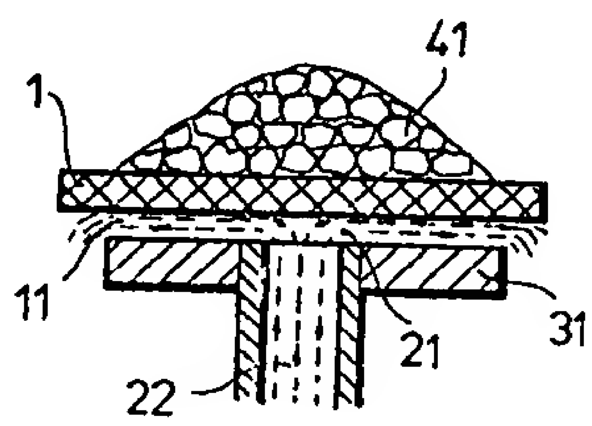

Fig.1

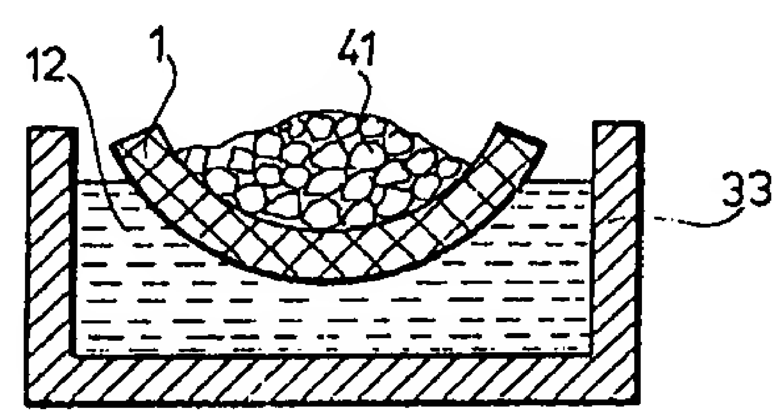

Fig.4

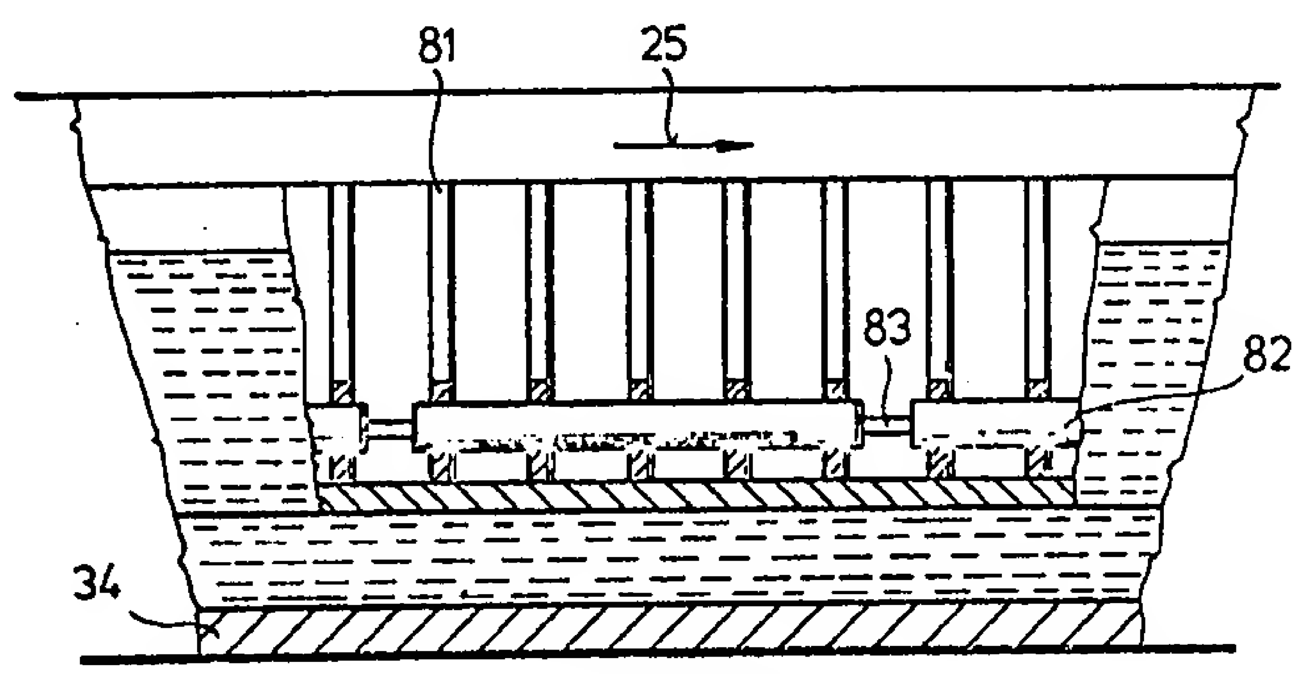

Fig.23

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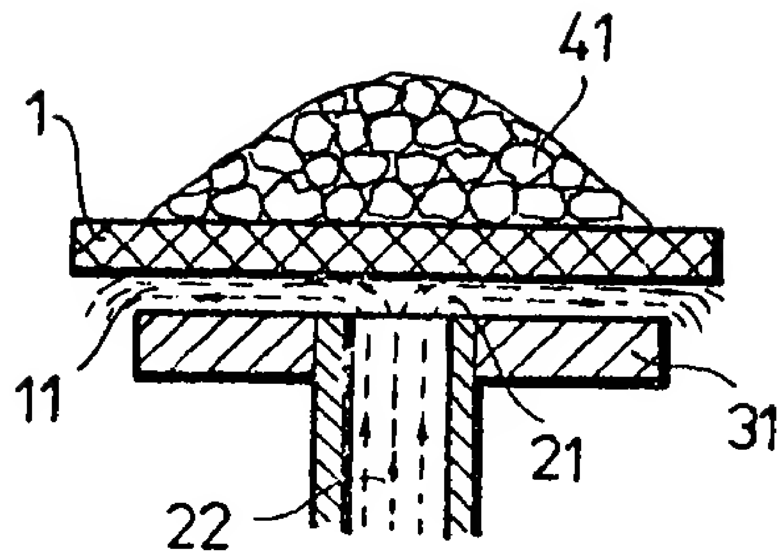

Fig.1

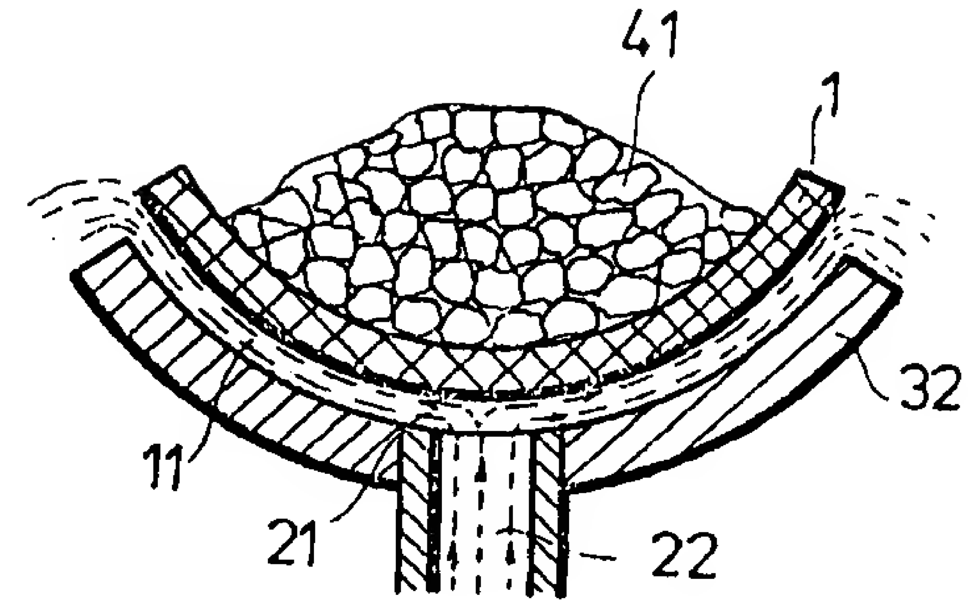

Fig.2

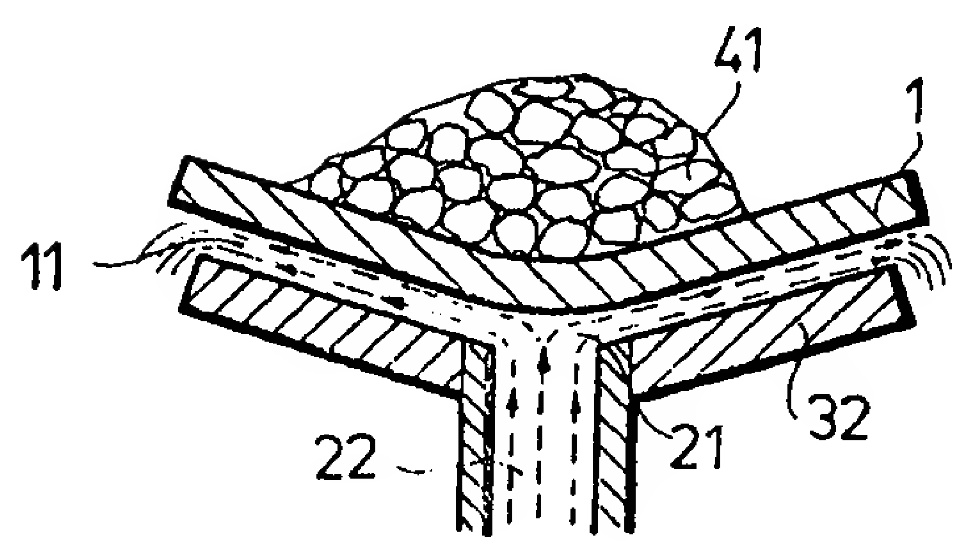

Fig.3

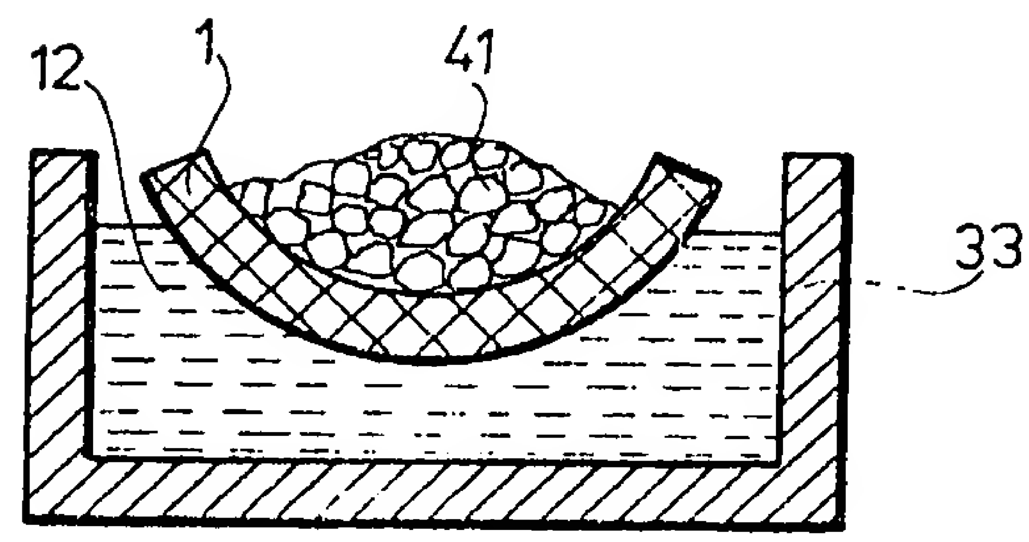

Fig.4

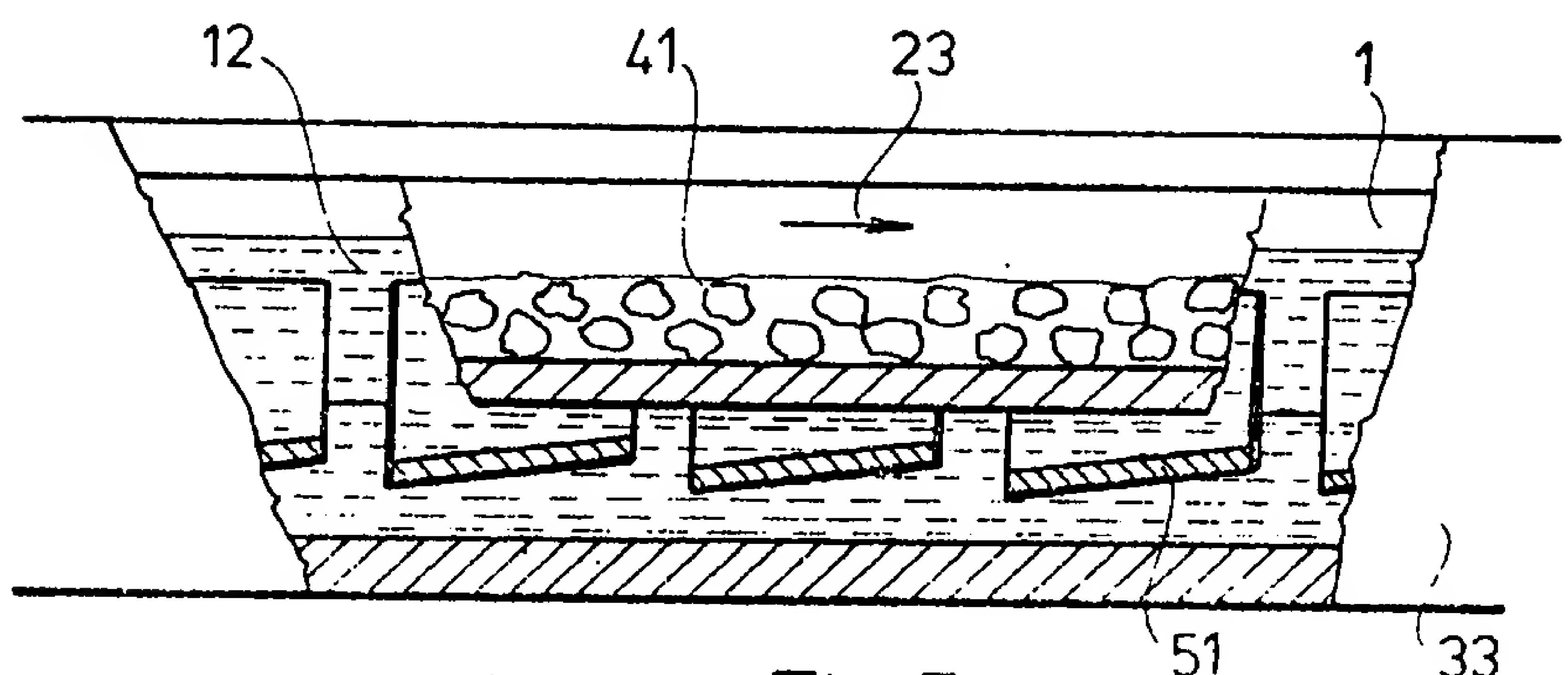

Fig.5

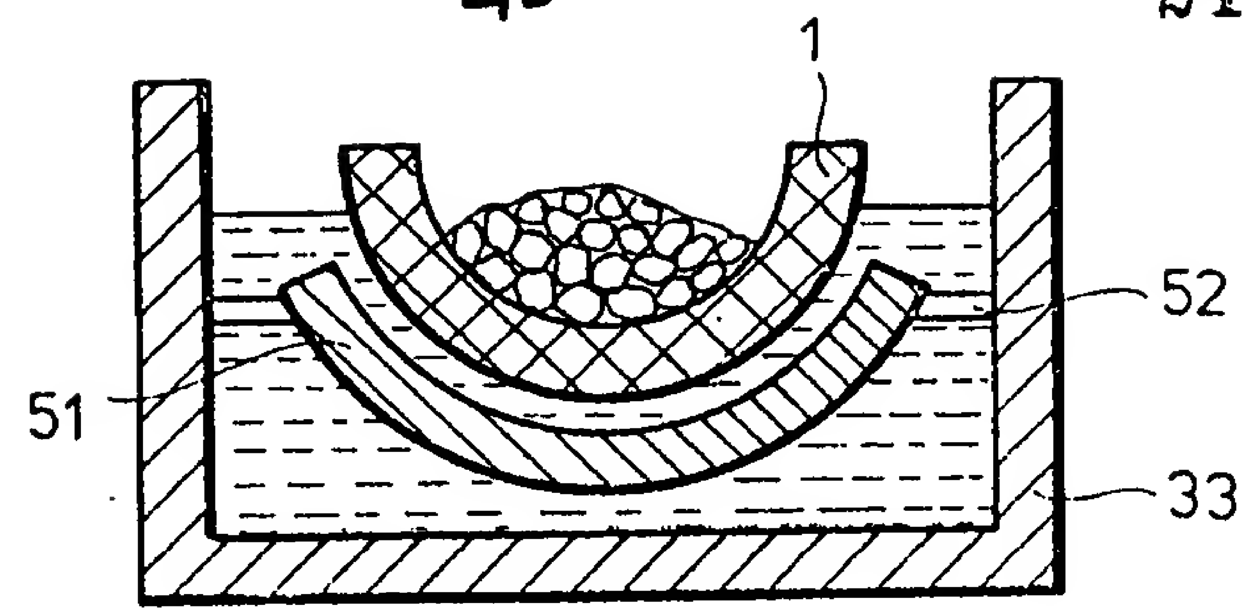

Fig.6

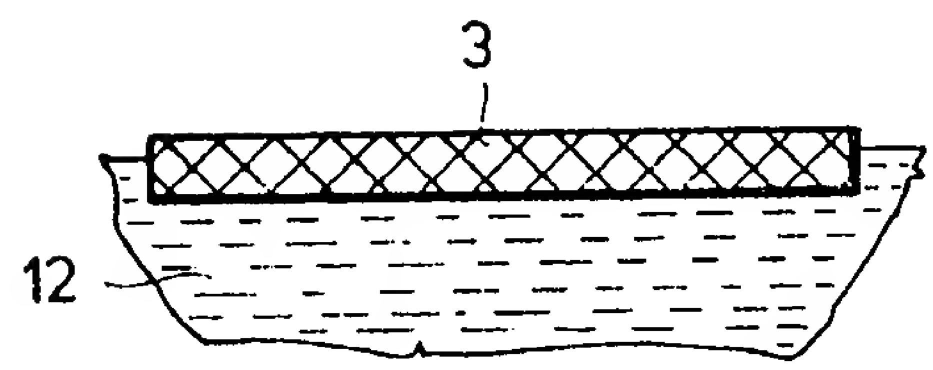

Fig.7

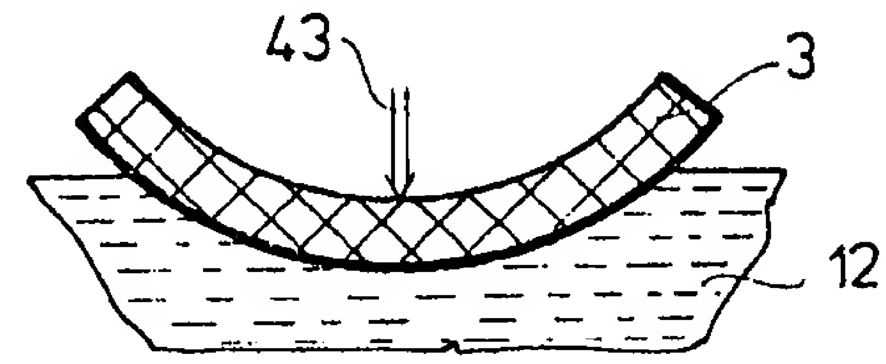

Fig.8

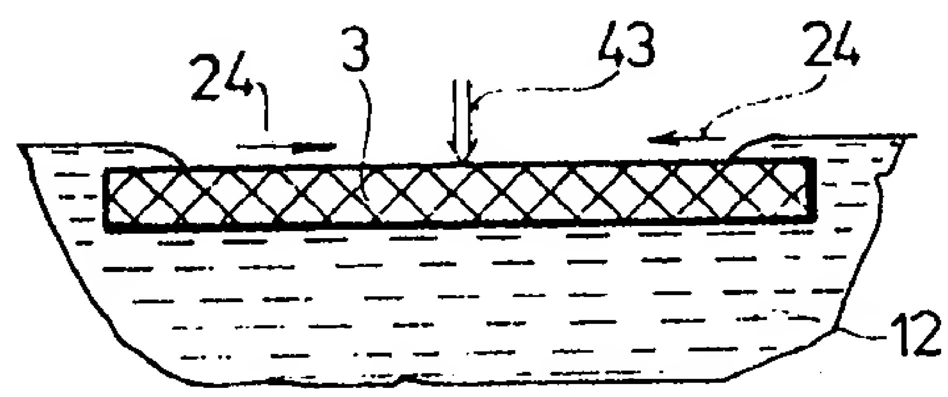

Fig.9

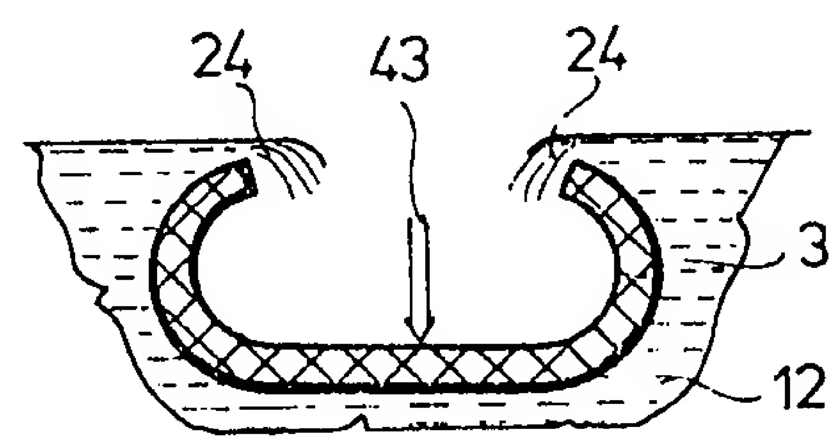

Fig.10

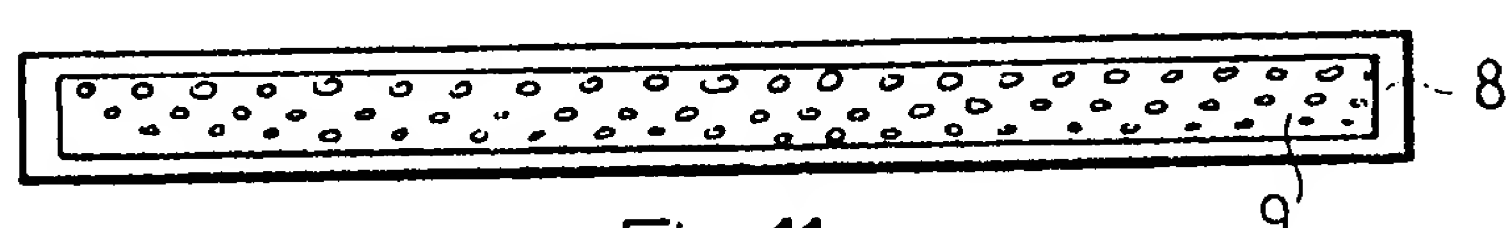

Fig.11

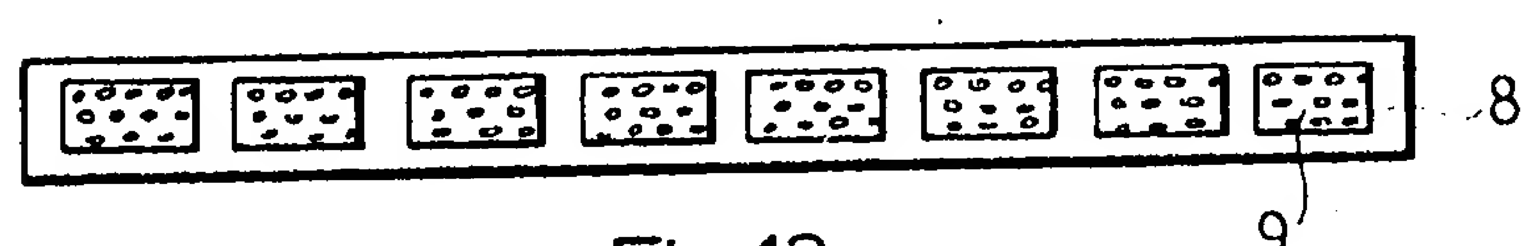

Fig.12

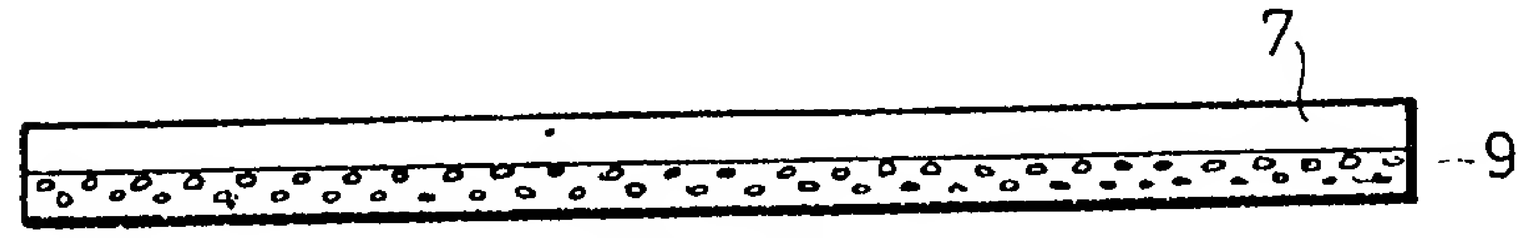

Fig.13

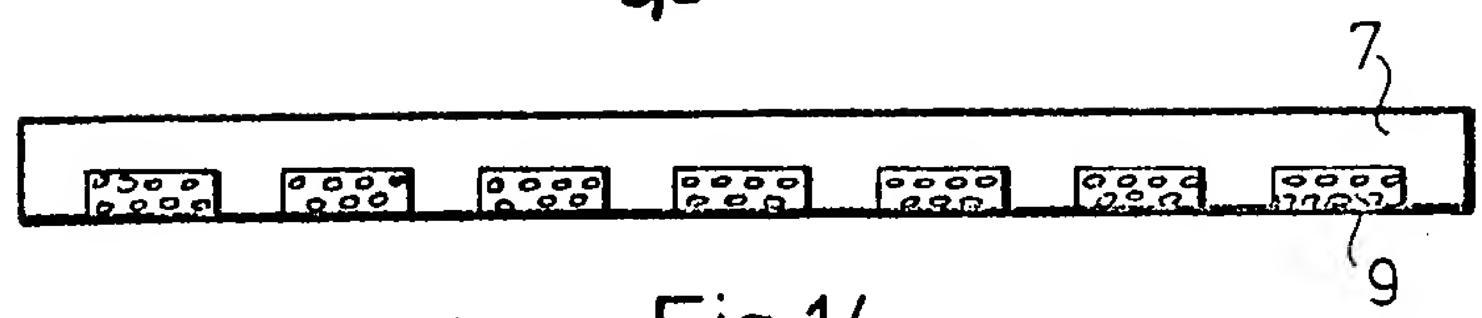

Fig.14

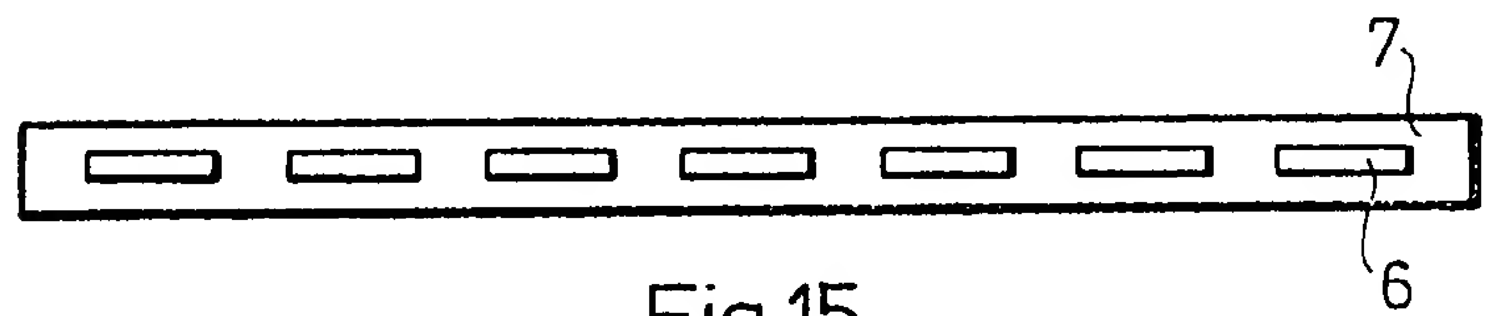

Fig.15

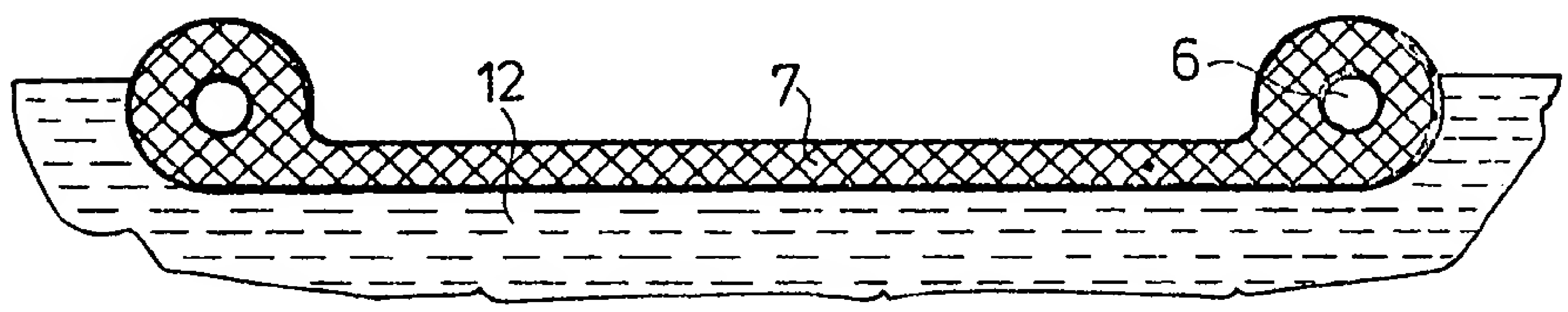

Fig.16

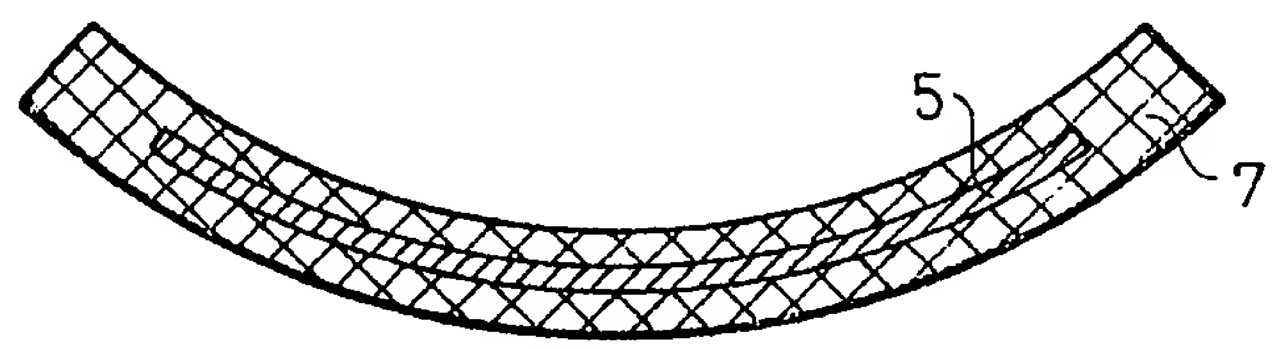

Fig.17

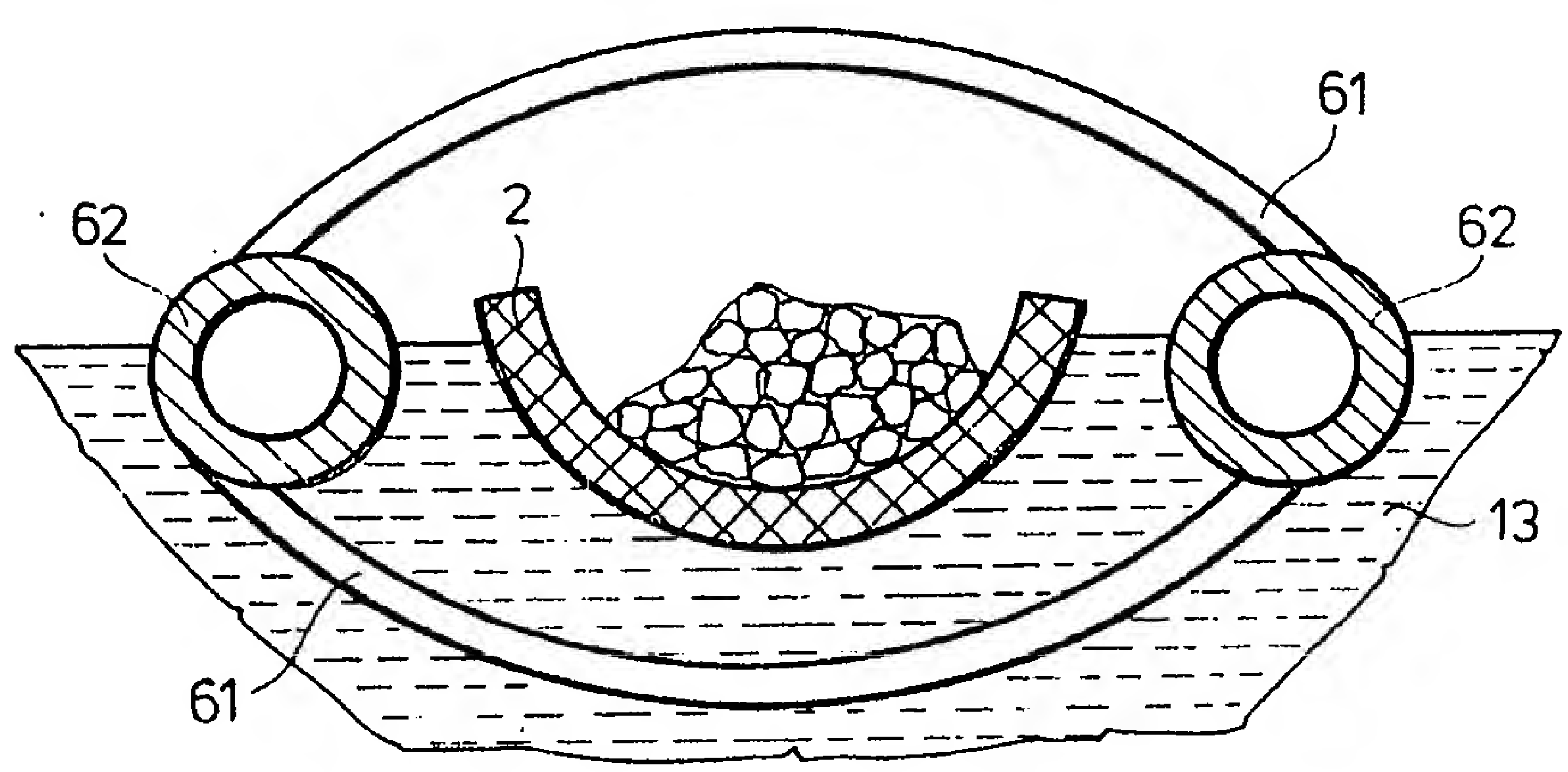

Fig.18

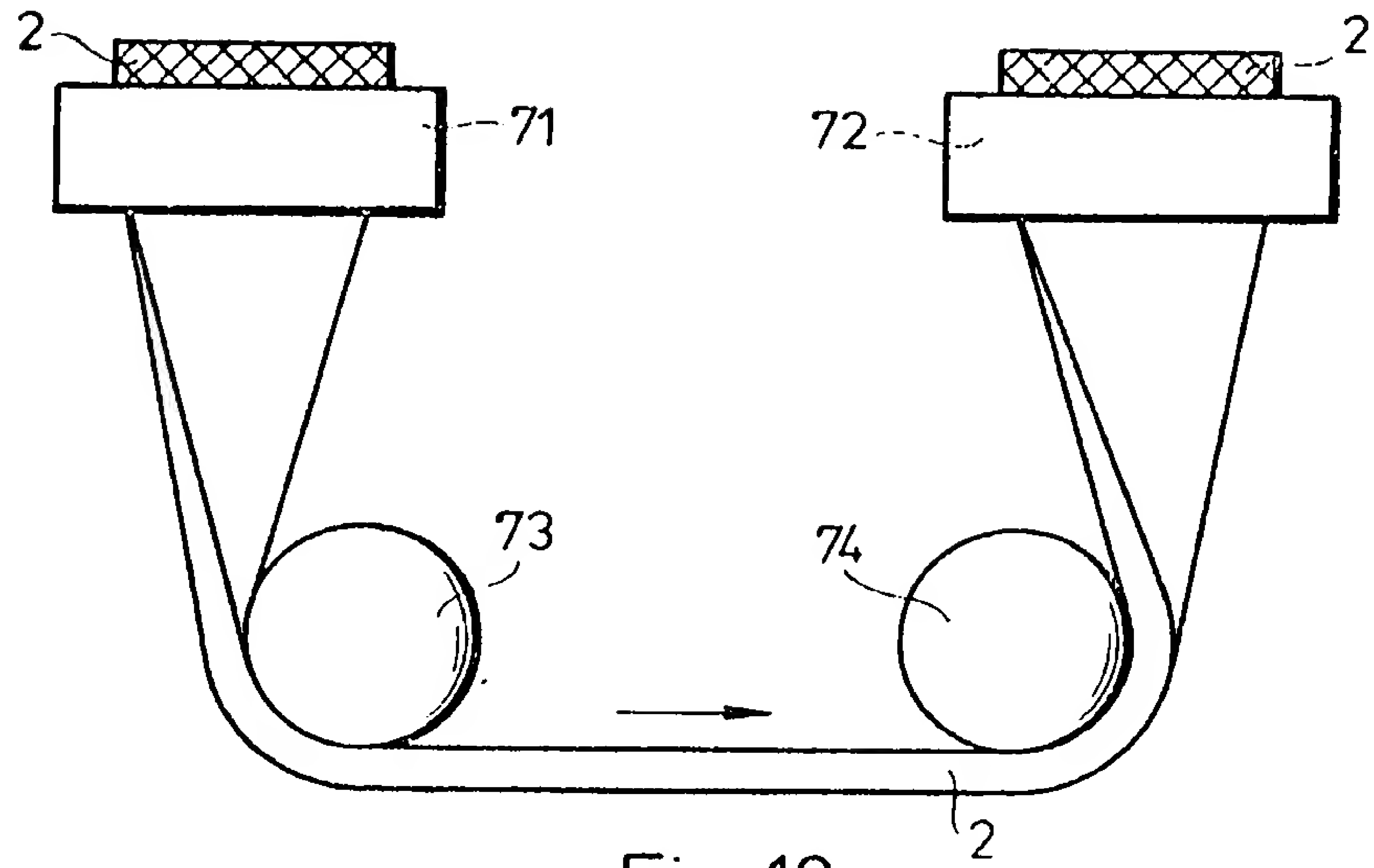

Fig. 19

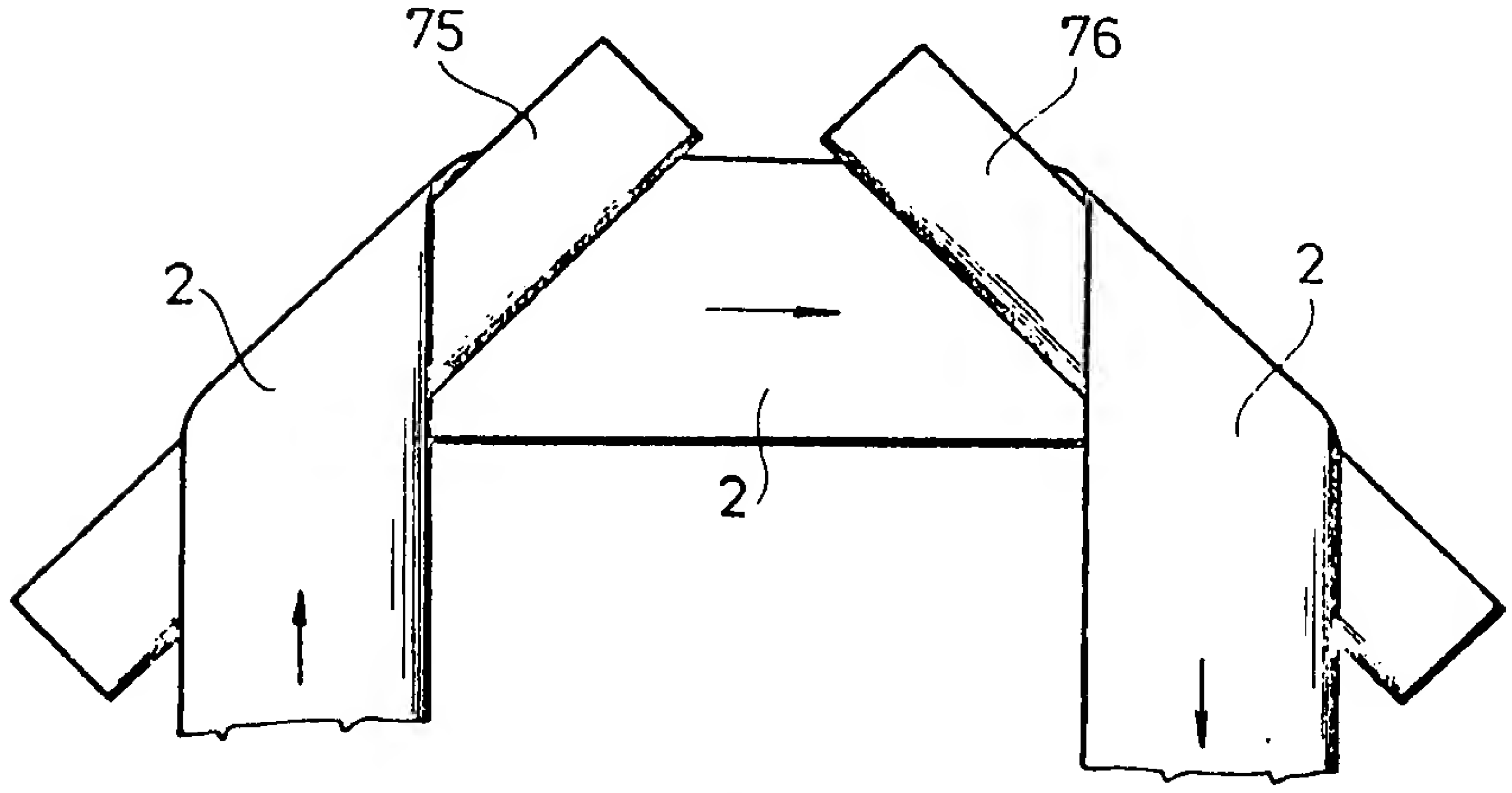

Fig. 20

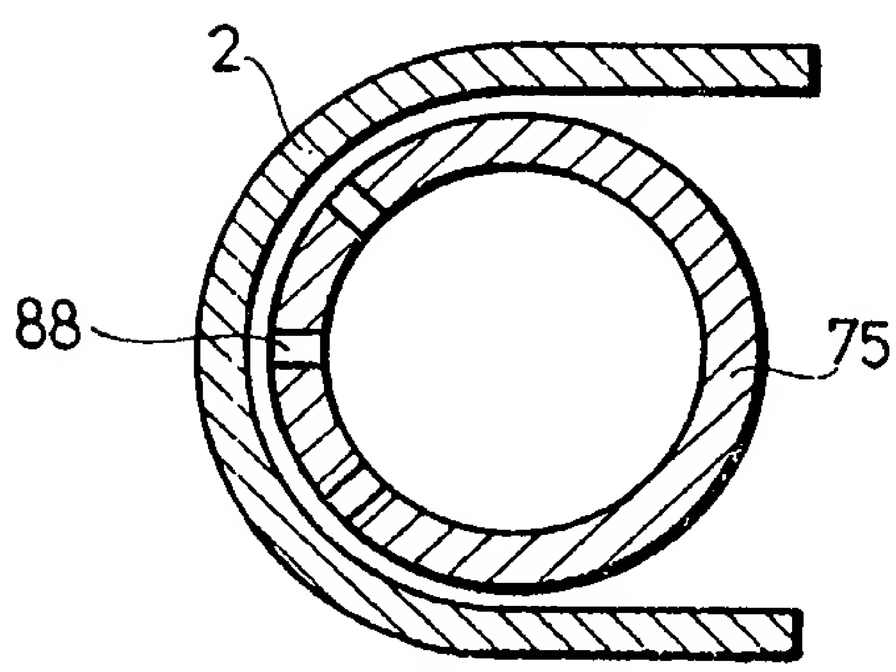

Fig. 21

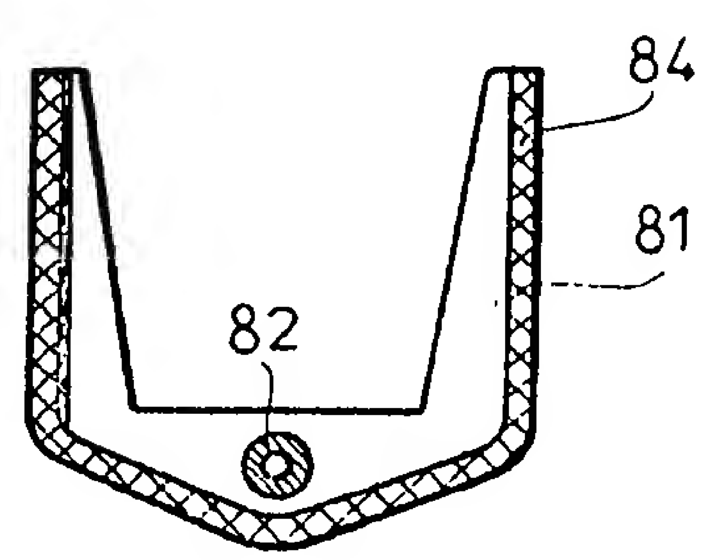

Fig. 22

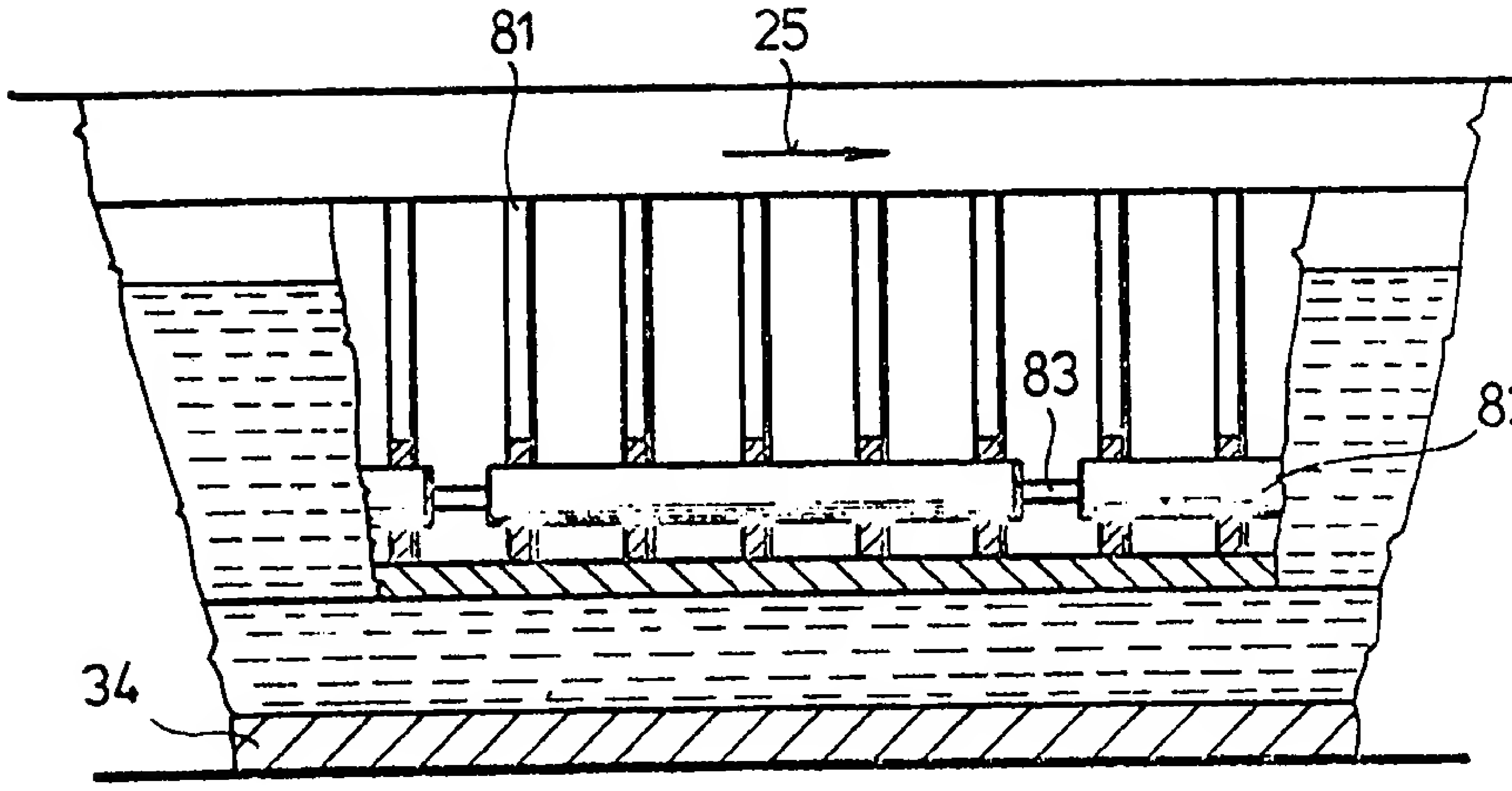

Fig. 23

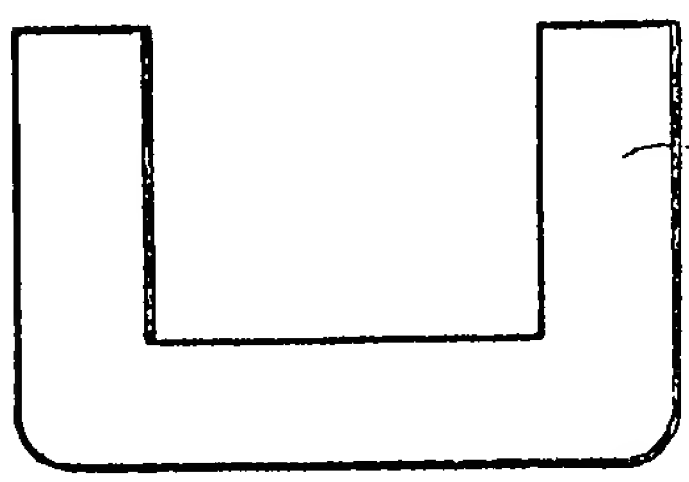

Fig. 24

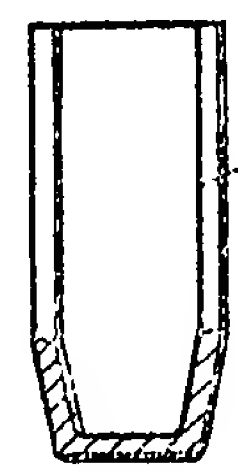

Fig. 26

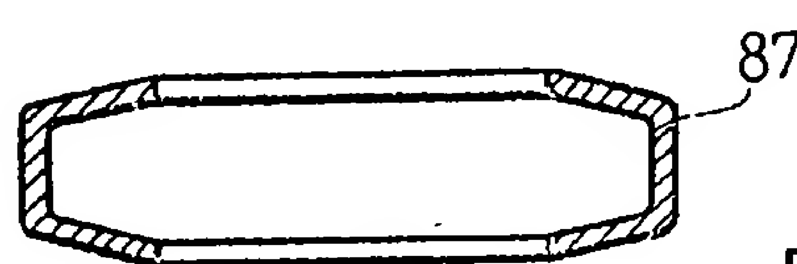

Fig. 25

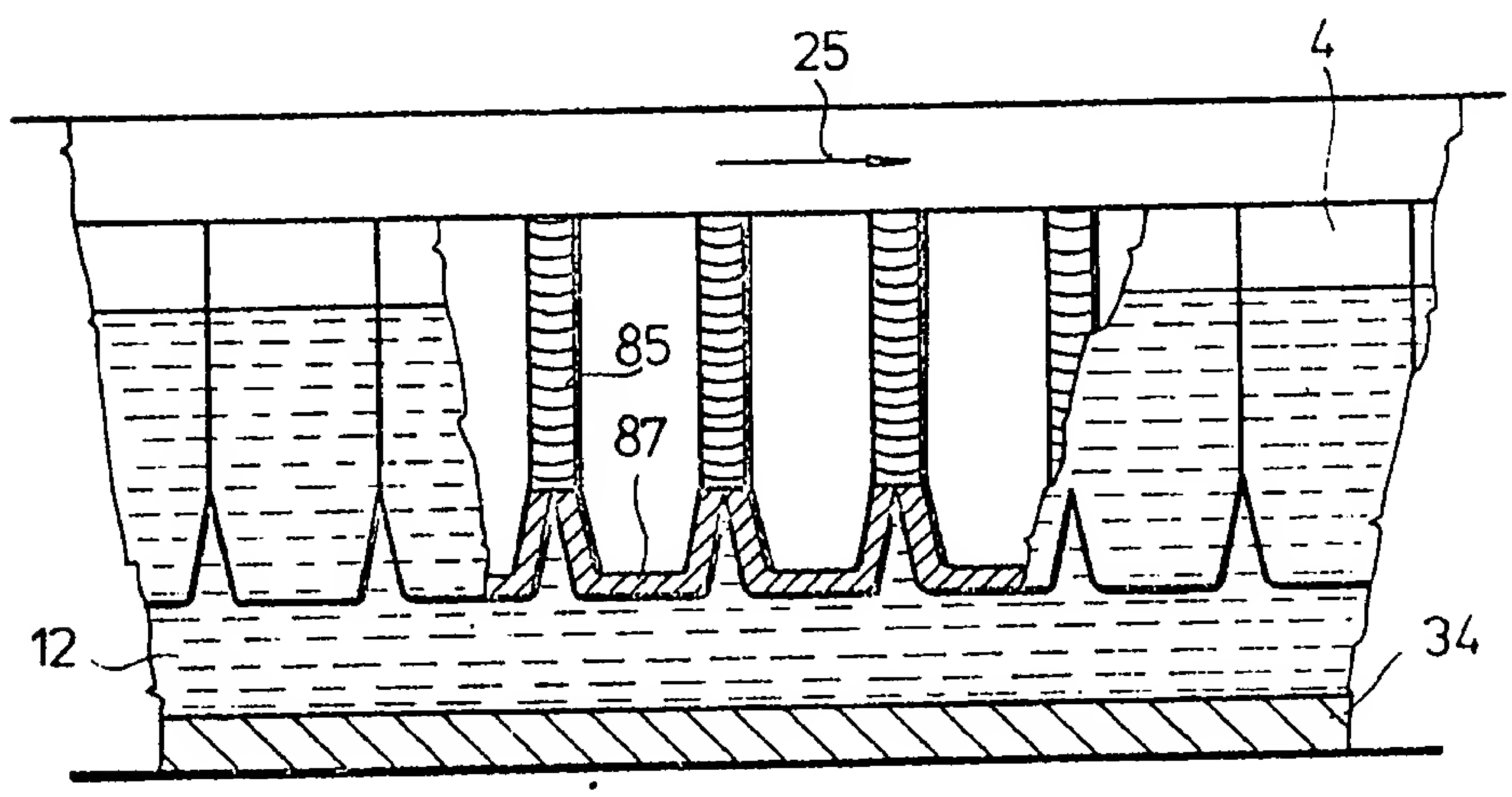

Fig. 27

SPECIFICATION

A process for the advancing of band-like transporting means with reduced friction and apparatus for carrying out the process

Field of the invention

The invention concerns a process for the advancing with reduced friction of longitudinally moved continuous band-like transporting means having a load carrier surface on their upper run and apparatus for carrying out the process.

Description of the prior art

Although the traditional conveyor belt may very advantageously be used as a transporting means, from a practical point of view it has several unfavourable characteristics. The belt is not supported continuously by the rollers, so the belt sags and in the course of its advance the material being conveyed performs a continual rising and falling movement. In order to diminish the sag the belt or band has to be tensioned (stretched) and has to be supported by rollers at relatively frequent intervals. The many bearings required for this purpose exert a high frictional force which continuously increases under the effect of contamination and in certain cases may cause fires by overheating. The cross-section of the belt cannot be formed in accordance with the most optimal operating conditions. The high friction and tensioning of the belt requires significant driving force and power. Because of this, the cross-section of the belt has to be increased, but even so, its length is rather restricted.

Attempts have been made to eliminate the above disadvantages by the use of air cushion conveying bands. In this known construction the band is moved within a profiled trough along the longitudinal axis of which air is pressed at regular predetermined intervals through inlet openings between the trough and the belt which closely fits it. In this way an air film of a thickness dependent on the in-flowing air is formed between the wall of the trough and the belt. The thickness of the film is a few tenths of a millimetre.

Although air cushion conveying bands significantly decrease friction, they nevertheless have two significant drawbacks. The first is that a significant part of the energy saving due to the reduction of friction has to be expended for feeding in the very high quantity of air required for creating the air cushion. The second disadvantage is that the air film is very thin and could only be made thicker to the required extent by using a disproportionately large amount of air.

The thickness of air film that can be achieved in practice enables the transportation of materials of small particle size only, e.g. wheat, because when larger pieces are transported large local deformations are created on the film side of the belt the magnitude of which breaks the air film and causes friction.

Summary of the invention

The aim of the invention is to eliminate or reduce the above drawbacks.

The primary task of the invention is to provide a process for the advancing of band-like conveying means with reduced friction wherein the in-feeding of the medium that reduces the friction requires no energy at all, or only a relatively negligible amount, and which enables non-uniformity loaded material of coarse particle size to be transported.

Another task of the invention is the provision of apparatus for carrying out this process.

The solution of the primary task is a process for advancing at reduced friction longitudinally moved continuous band-like transporting means, especially conveyor bands having a carrier surface on their upper run wherein, in accordance with the invention, the lower run of the transport means is placed at least in part on a layer of liquid and the carrier surface of the transport means is prevented from coming into communicating contact with the liquid layer.

In a preferred embodiment of the process according to the invention the liquid layer is formed by a liquid fed in under pressure. In another preferred embodiment, the liquid layer is formed from a liquid passed onto a supporting means placed beneath the transporting means which supporting means at least partly follows the lower underside of the transport means.

In a further preferred embodiment, the liquid layer is formed at least in part in a liquid reservoir arranged beneath the transport means.

Communicating contact between the transport means and the liquid layer is prevented advantageously by raising the two sides of the transport means relatively to its central part.

Furthermore, it may be advantageous to use an artificial canal for the liquid storage means or reservoir. It may also be advantageous if the liquid reservoir is a natural standing or running water.

In another advantageous embodiment the pressure of the liquid is artificially increased.

In a further advantageous embodiment, the pressure of the liquid is increased by exploiting natural level or height differences.

One solution of the secondary task is apparatus for carrying out the process according to the invention which comprises a continuous band-like transport means, supporting means for at least intermittently supporting the transport means and driving means for the transport means wherein, in accordance with the invention, the transport means, expediently a belt, is supported by a supporting element in the form of a support plate which at its surface adjacent the transport means is in communicating contact via an inlet feed duct with a source of liquid.

In a preferred embodiment of this apparatus, the support plate is of concave cross-section when viewed from the transport means.

In another advantageous embodiment, the feed duct is connected in the region of the central longitudinal line of symmetry of the transport means.

In another advantageous embodiment the supporting plate is at least intermittently of raised construction, i.e. has salients, in the direction of advance of the transport means.

Another solution for solving the secondary task is apparatus for carrying out the process according to the invention which comprises a continuous band-like transport means, an element for at least intermittently supporting the transport means and drive means for the transport means, wherein at least a portion of the transport means is placed on a liquid layer arranged in a liquid storage reservoir, expediently a trough, and is of concave cross-section when viewed from above.

In a preferred embodiment of this apparatus, the transport means is formed from a material of an average density less than that of the liquid.

In another preferred embodiment, the transport means is provided with a density-reducing insert.

In a further preferred embodiment, at least one closed cavity is formed in the material of the transport means.

Advantageously, the transport means may be provided with a stiffening insert.

It may also be expedient if there is a closed cavity arranged to extend longitudinally at the two side edges of the transport means.

In another advantageous embodiment, protective barriers floating on the surface of the liquid are arranged at the two sides of the transport means and are expediently connected together expediently by spacers.

In a further preferred embodiment, on the internal side opposite the liquid the transport means is provided with ribs extending transversely relative to the direction of advance.

Advantageously, the transverse ribs are U-shaped. Furthermore, it may be expedient to provide the U-shaped ribs with bores on their lower throughgoing sections, with longitudinal stiffening elements, expediently tubular members, threaded through these bores.

It may furthermore be favourable if the longitudinal stiffening elements, expediently tubular pieces, have flexible elements interposed between them.

Finally, the transport means may advantageously consist of U-shaped and U-section belt elements, expediently transversely sectioned tyres which are united together at their end faces.

Brief description of the drawings

The invention is described, merely by way of example, with reference to preferred embodiments illustrated in the accompanying purely schematic drawings, wherein:

Figure 1 is a cross-section of a first embodiment of the apparatus according to the invention, taken in a plane at right angles to the direction of its advance, the apparatus being provided with a horizontal straight supporting plate;

Figure 2 is a cross-section similar to Figure 1 but showing a second preferred embodiment of the apparatus provided with an acuate supporting plate which, viewed from above, is of concave cross-section;

Figure 3 is a cross-section of a further embodiment of the apparatus, here provided with a supporting plate of V-shaped cross-section;

Figure 4 is a cross-section of another embodiment of the apparatus, here provided with a liquid storage trough;

Figure 5 is a longitudinal section of the apparatus provided with a liquid storage trough and intermittently arranged, arcuate supporting plates;

Figure 6 is a cross-section of the apparatus according to Figure 5;

Figure 7 is a cross-section of an unload transport belt placed in a liquid reservoir;

Figure 8 is a cross-section of the same belt as in Figure 7 but when supporting a load concentrated along the central axis of the belt;

Figure 9 is a cross-section of another transport belt, similarly loaded;

Figure 10 is a cross-section of yet another belt, similarly loaded;

Figures 11 to *15* show various transport belt cross-sections respectively provided with density-reducing inserts;

Figure 16 is a cross-section of transport belt provided with longitudinal, closed cavities extending along the two side edges of the belt;

Figure 17 is a cross-section of a belt provided with an arcuate stiffening insert;

Figure 18 is a cross-section of the apparatus provided with protective barriers;

Figures 19 and *20* are respective diagrammatic plan views of belt turning (direction-changing) devices;

Figure 21 is a cross-section of a cylinder for effecting belt turning or angular displacement;

Figure 22 is a cross-section of a ribbed transport means;

Figure 23 is a longitudinal cross-section of apparatus provided with transporting means according to Figure 22;

Figure 24 is a front view of a belt element of U-shape and U-shape cross-section;

Figure 25 is a plan view of the belt element according to Figure 24;

Figure 26 is a side view of the same belt element;

Figure 27 is a longitudinal section of apparatus provided with transport means made up of belt elements according to Figures 24 to 26.

Description of the preferred embodiments

In the preferred embodiments according to Figures 1 - 3 a belt 1 for carrying material 41 to be conveyed is provided with a supporting plate 31 or 32 and a liquid 11 is caused to flow along the directions indicated by the arrows 21 from the centre of the belt towards its edges. The liquid 11 is fed under pressure from an inlet duct 22 connected to the centre of the supporting plate 31 or 32 and thus passes between the supporting plate 31, 32 and the belt 1. The liquid 11 forms a film which exits at the edges of the supporting plate 31 or 32.

In Figure 1, the film formed by the liquid 11 flows along the arrow 21 caused by the pressure gradient which forms between the centre line of belt 1 and the edges of the supporting plate 31. The pressure gradient represents an overpressure p(x) in the liquid relative to the ambient pressure. At the exit or discharge point the value of p(x) is nearly zero. The buoyancy force exerted on the belt 1 maintains an equilibrium with the force of gravity exerted on the belt and on the material loading the belt. As the loading force increases a new equilibrium is formed by a reduction of the thickness of the film and thus the pressure gradient increases. Related to a unit of length of the belt the following formula can be described:

$$g(f_{sz} + f_t) = 2\int_{l=0}^{l=h/2} p(l).dl \qquad (1)$$

wherein

f_{sz} is the mass of the belt per unit length;

f_t is the mass loading the belt per unit length;

g is the gravitational constant;

p(l) is the excess pressure of the liquid at a distance l from the longitudinal axis of the belt and h is the width of the supporting plate 31.

Figure 2 shows an example wherein, when viewed from above, the supporting plate 32 is concavely arcuate. The liquid 11 between the belt 1 and the supporting plate 32 forms a film in which a part of the pressure gradient arising lifts against the gravitational force and only the remainder assures circulation of the liquid. This embodiment is in two respects more advantageous than that of Figure 1. On the one hand, it enables an appreciably greater quantity of material 41 to be conveyed and, on the other hand, the lengthening of the film formed in and from the liquid and the appearance of a hydrostatic pressure result in less liquid flow being necessary to maintain the film.

Figure 3 illustrates an embodiment similar to that in Figure 2 but with a difference that here the supporting plate 32 is not of part-circular cross-section but is of V-shaped cross-section. The hydrostatic pressure may of course be produced also with supporting plates of other shapes.

Figure 4 shows an example wherein the equilibrium between the gravitational force acting on the belt 1 and on the material 41 conveyed on the belt is fully balanced by the hydrostatic pressure of the liquid 12 on the belt 1. In this embodiment the need for pumps maintaining the liquid film is obviated but on the other hand care must be taken to ensure that the belt 1 should have a shape-retentive profile: a few examples of this will be given below.

Figures 5 and 6 show an embodiment in longitudinal section wherein the belt moving in the direction of arrow 23 entrains by friction the liquid beneath it, whereby a liquid film is formed in the tapering or narrowing gap between the belt 1 and curved support plates 51 formed as baffle plates. The longitudinal profile or cross-sectional shape of the supporting plates 51 on the side of the belt 1 may be non-linear in the interest of the thickening of the liquid film. This solution has the disadvantage compared with the previous embodiment that the initial friction of the belt is large. This, however, can be mitigated or overcome by forming a liquid film in accordance with Figure 1, until the belt 1 has accelerated to its full speed. The advantage of this embodiment is that the belt 1 need not be of stable, shape-retentive. Figure 6 is a cross-section of the apparatus shown in Figure 5 and shows that the supporting plates 51 are fastened to the side walls of a liquid-storing trough 33 by means of supporting elements 52.

In every one of the above embodiments the moving belt is in frictional contact with a liquid and therefore the friction is low. The thickness of the liquid film is sufficiently great for the film not to be broken by the non-uniformities present on the belt surface due to the piece-like nature of the material.

In the embodiment according to Figure 4 if the transport path is horizontal there is no need for a pump for displacing the liquid and if the path is on a gradient only at the start up is it necessary to provide a pump. This characteristic represents an advantage primarily for slow-moving or intermittently-moving bands or belts.

In the embodiments illustrated in Figures 1, 2, 3 and 5 any conventional belt or steel band may be used.

In the embodiment of Figure 4 positive measures are required to ensure that the belt should float on the surface of the liquid and that the liquid should not be able to penetrate to the carrying surface. In Figures 7 to 12 such measures are illustrated.

Figure 7 shows a construction wherein the belt 3 is made of a flexible material of lower average density than that of the carrying liquid and thus it floats on the surface of the liquid 12.

Figure 8 illustrates that this same belt 3 curves upwards at both edges under the effect of the concentrated load (arrow 43) exerted along its longitudinal axis and thus its carrying surface cannot receive liquid in spite of the fact that the central region of the belt 3 is more deeply immersed in the liquid 12, relative to the unloaded condition. In addition to the choice of the average density of the belt, it is also necessary appropriately to design the flexural or bending strength of the belt to ensure that on being loaded the belt 3 should behave as shown in Figure 8 and should not be submerged. Where the flexural strength is so great that on being loaded the belt 3 behaves in a rigid fashion, i.e. its edges do not curl up (Figure 9) then the level of the liquid 12 can rise above the level of the belt 3 and the liquid 12 can flow in the direction of the arrows 24 to reach the carrier surface. Where, on the other hand, the transverse flexural strength of the belt is too small, then under the effect of the load designated by the arrow 43 the belt 3 is submerged in the liquid 12 (Figure 10) since the edges of the belt are bent inwardly by the buoyancy force of the liquid and the liquid 12 penetrates the direction of the arrows 24 into the space delimited by the belt 3.

The average density of the belt 3 conforming to the desired conditions is assured by the choice of a suitable material, e.g. a polyethylene or a polypropylene. Naturally, it is not necessary that the material of the belt 3 should by unitary, the essential factor is that the average density of the belt 3 should be less than that of the liquid 12.

Figure 11 shows a variant of the embodiment of the belt 3 according to Figure 7 wherein a density-reducing insert 9 of a continuous internally porous material is surrounded by a continuous mantle or jacket 8. In this embodiment it is unconditionally necessary that the insert 9 and the jacket 8 should form a coherent whole. It may, for instance, be suitable to use a textile insert to the surface of which a well-adhering rubber is applied, but it may also be advantageous if the internal component of the belt material is made from a foamed material.

In the case according to Figure 12, the core or frame of the belt 3 is formed by the jacket 8 and thé insert 9 of porous material is not organically connected with it. In this embodiment care must be taken for the intermittent joining of the two sides of the jacket 8.

Where a foam of closed pores or other porous material is used, the construction according to Figure 13 may also be suitable. Here the layer 9 of a closed pore material is disposed beneath the belt body 7.

Should the carrying capacity of the foam of closed cells or the porous material be insufficient, then the belt of the construction in Figure 14 may be utilized, wherein longitudinal grooves formed on the underside of the belt are filled with porous inserts 9.

Figure 15 shows an example of a construction for the belt 3 wherein the average density is reduced by using cavities 6 containing air. For this embodiment, the material of the belt must naturally bé chosen to be stronger so that the unfilled cavities 6 should maintain their shape. The cross-sectional form of the cavities 6 may be chosen as desired, but as regards their longitudinal shape it is expedient to divide them into sections so that in the event of a fault, any liquid penetrating should not fill the whole cavity volume.

In the construction shown in Figure 16 the reduced density is not provided across the full cross-section of the belt but only at the two edges of the body of the belt 7 by the use of cavities 6 to reduce the average density to a value lower than that of the liquid. In this way even in an empty or unloaded condition the belt would not sink in the liquid 12. The flexural rigidity or bending strength of the belt must in this case also fulfil the conditions described in connection with Figures 8 and 9.

In the embodiment according to Figure 4 a belt 1 may also be used which has an average density greater than that of the liquid 12. In this case the belt must be so formed that even in their unstressed condition its edges should curve upwardly and, after straightening, the belt should resiliently regain its upwardly curving shape. In the loaded condition the radius of the curvature of the belt floating on the surface of the liquid 12 is smaller than in the empty or unloaded state. The belt cross-section required for this can be assured by means of a band made of steel or glass or reinforced polyester. In the case of a plastics or rubber band the required cross-section can be assured by arcuate stiffening inserts 5 made from steel spring, as shown in Figure 17. The inserts 7 are built into the band at a density or distribution that they should maintain the arcuate cross-section along the full length of the band.

The liquid carrying the belt should in every case be chosen in acordance with the external conditions. In the embodiments according to Figures 1, 2 3 and 5 it is more advantageous to use a liquid of high velocity because then a pump of lower capacity is required to assure the formation of the liquid film. In contrast, in the embodiment of Figure 4 it is more advantageous to use a liquid of lower viscosity because this will require less power to move or advance the belt.

The carrier liquid selected is generally water because this is the cheapest and is the medium which is available virtually everywhere in large quantities. When the weather is cold, protection against the water freezing over may be provided by adding various salts to it. Particularly advantageously metallic salts may be added which also increase the density of the liquid and thus render it necessary to use special low density bands or belts. If polymers are dissolved in the water then the liquid may, if needed, be rendered suitably water-repellant.

In the embodiments according to Figures 1, 2 and 3 the supporting plates 31, 32 coming into contact with the belt 1 are expediently so formed that in the direction of advancing movement of the belt their friction should be as low as possible while in the direction perpendicular to that movement it should be as large as possible. The carrier liquid is fed in either through a slot or numerous inlet apertures provided at frequent intervals along the centre line of the support plates 31 and 32. The infeeding may be effected by a pump or, if available, via a suitable natural water reservoir disposed at a higher level, by gravitation.

In the system shown in Figures 4 and 5 the liquid reservoir containing the carrier liquid may be formed in many ways, depending on the local circumstances.

One possibilty is the use of trough elements juxtaposed and suitably matched so as to combine them into a continuous canal. The locations of the joints should be suitably sealed or the whole canal should be provided with a continuous lining to prevent the liquid from discharging. The continuous lining may, for instance, be formed from a plastics foil.

In given cases it is not necessary to provide an artificial canal along the full length of the belt for the carrier liquid. At individual sections or even along the full length of the belt the carrier liquid may naturally be constituted by the water of lakes or rivers. The disturbing effect of surface movements of the water may be eliminated, if required, by the method illustrated in Figure 18. In this embodiment at the two sides of the belt 2 floating on the surface of a natural water 13 there are provided protective barriers 62 made from a material of an average density lower than that of water, the barriers being connected together at intervals above and below the belt 2 by means of arcuate spacers 61.

In the embodiments according to Figures 4 and 5 the liquid in the trough 33 moves in the longitudinal direction along with the belt 1. The mean velocity of the liquid is approximately one-half the mean velocity of the belt when the belt moves along the horizontal path. The mean velocity of the liquid deviates from this velocity, depending on the magnitude of the ration of the wetted surface area of the belt to that of the canal and on the difference between the roughness of these surfaces.

When the belt is moving upwardly, the velocity of the liquid is reduced by an extent corresponding to the back-flow on the gradient between the belt and the trough. Naturally, when the belt run moves downwardly the velocity of the liquid increases.

In the final analysis, the belt carries the liquid from one end station or terminus of the transport path to the other. If it is desired to remove the need for constantly supplying further liquid then the liquid can be recirculated to the starting point either via the duct or within the return run of the belt, and in this way the liquid can be kept in constant recirculation.

There may be salients along the path of the belt where the thickness of the liquid film reaches the desired value only if the belt has a suitable velocity. Hence at these locations supplementary quantities of liquid may have to be fed in from time to time when the belt starts or when it moves at low speeds.

If it is desired to utilize both runs of the belt for conveying materials then at the end stations or termini a belt-turning construction has to be used to ensure that the load-conveying surface of the belt should face upwardly along both runs. Such a construction is shown in Figure 19. Here the belt 2 runs onto a tensioning drum 71 and from there to drums 73, 74 the axes of which are at right angles to the drum 71. From the drums 73, 74 the belt runs onto another tensioning drum 72 which is coaxial with the tensioning drum 71 and so perpendicular to the drums 73, 74; from the tensioning drum 72 the belt is run off. In this way the two runs of the belt advanced in mutually opposite directions move mutually in parallel and the conveying surface is directed upwardly in both runs.

In the embodiment according to Figure 20, the turning cylinders or drums 75, 76 are provided with an air cushion or liquid cushion and their axes are mutually perpendicular. The two runs of the belt 2 run at an angle of 45° to the turning drum 75 and run off at the same angle from the turning drum 76, that is to say, they run in parallel. The turning drums 75 and 76 are non-rotary and in the manner shown in Figure 21 pressurised air or liquid is caused to flow via apertures 88 between their outer surface and the belt 2, so that the belt 2 is advanced on the film that is formed in this way.

The constructions according to Figures 19 and 20 enable a change of direction of not only 180°, but other angles also if the axial orientations of the belt-turning drums are suitably altered. However, in this case not two, but three or more end stations according to Figures 19 or 20 are required but, on the other hand, transport in a non-linear direction or covering a given area by a circular run with several loading stations are rendered possible.

In the embodiment according to Figure 20, a separate driving drum is required to drive the belt 2, while in the embodiment according to Figure 19 the tensioning drum 71, and if desired the tensioning drum 72, as well as the drums 73, 74, may be used for driving the belt. The belt 2 may also be driven by a linear electric motor if in the system of Figure 17 the belt is provided with a metallic insert or is fully metallic.

Whichever method of driving is utilized, regard must be had to the fact that the power consumption in driving the conveying belt is the lower the slower the speed of conveying a given quantity of material. It is

therefore expedient to run the belt at a speed ensuring that it is full. Additionally, experience has shown that for a fault free or disturbance-free operation of the belt it is necessary to ensure that the load per unit length of belt does not change suddenly. Both of these factors require that an automatic speed control unit should be provided for the drive which can alter the speed of the belt as a function of the quantity of material waiting to be conveyed.

Discharge of the belt may be accomplished by using the tensioning drum 71 shown in Figure 19 or the turning drum 75 shown in Figure 20 at the termini but, analogously to the transport belts provided with rollers, belt-emptying or discharging drums may be provided at any location along the longitudinal axis of the belt. The feeding of the material to the belt can take place with the same means which are used for the roller-driven transport belts. The wear on the carrier surface on the belt and the traction force requirements may be reduced to a fraction of their usual values by passing the material at an accelerated rate to the belt when material is fed onto it so as to ensure that the belt itself does not have to expend work to accelerate the material.

In the belt construction described so far, a change of direction may only be accomplished by a sudden break and only at sections which do not carry material. Figure 23 shows a construction wherein it is possible to change direction even without a break and even whilst the belt is loaded.

In the system according to Figures 22 and 23, the belt 4 advances in the direction of arrow 25 in a trough 34, Figure 22 being a partial longitudinal section of the trough 34 and to a lesser extent of the belt. On the inside of the belt there are upwardly open equispacedly arranged U-shaped ribs 81. The lower, yoke or base of the U-shaped ribs 81 are provided with bores at the centre line of the belt through which tubular members 82 are threaded to serve as stiffening elements. The individual tubular members 82 are connected together by flexible elements 83. In given cases the elements 83 may be of stranded cable. In Figure 22, which is a cross-section of the ribbed belt, it may be seen well that the ribs 81 is surrounded by a continuous cover plate 84 which forms the actual belt.

The ribs 81 are distributed along the belt at a frequency ensuring the desired flexure along the longitudinal axis, both in a horizontal plane and a vertical plane. This is because the extent of flexure or bending is limited by contact or abutment between the ribs 81.

Figures 24, 25 and 26 show a construction wherein there is no need for a separate covering plate. Here belt elements 87 are employed which both in side view (Figure 24) and in section (Figures 25, 26) are U-shaped. These belt elements 87 are similar to rubber tyres which have been cut in two in an axial direction and which may in given cases actually be such sectioned rubber tyres, and along their end surfaces they are welded or bonded together into a belt 4 according to Figure 27. In other respects the construction according to Figure 27 is similar to that according to Figure 23, except that there is no need to provide the tubular elements 82 and the elements 83. The belt elements 87 are vulcanised or welded or stuck together along seams 85. This construction may be utilised without further measures for slowly moving belts because there the resistance of the medium is not significant. However, for high-speed belts the resistance increases at the locations of the joints between the belt elements 87 and therefore for such cases it is expedient to utilise a covering plate according to Figure 23, but with a difference that it may even be made from a liquid-permeable material.

The transport device according to Figures 23 and 27 can be guided in a horizontal plane in such a way also that they are arcuately curved by creating a suitable liquid cushion between the internal curved surface of the trough 34 and the belt.

If it is required to move the belt along a regular circle then it is not necessary flexibly to couple the ribs 81 together, and dependent on the radius of the desired circle, it may be possible to use a rigid but suitable curved coupling, i.e. the whole belt may be produced in the form of a continuous ring.

The system according to the invention has a number of advantages relative to the known transport or conveyor belts employing rollers and air cushions. Elimination of the rollers have the following advantages:

- the manufacturing costs of the apparatus are reduced because there is no need for the large number of rollers, bearings and the usual devices connected to these;
- there is no need to clean or maintain the transporting device;
- a given transporting task can be solved with a thinner belt which is an advantage both from the point of view of investment costs and operating costs;
- one drive means can drive a longer transport device;
- over an extended operating period the usual gradient increase in the frictional force, which always happened with roller-driven belts because of the gradual contamination of the bearings, does not occur;
- the running of the tranport device is smooth, it does not break up the material being conveyed because the wavy or oscillating material due to the sag of the belt betwen the rollers is eliminated.
- both runs of the belt can effect transportation;
- the belt runs may be connected not only in parallel but also in an arcuate path at an angular break. By suitably choosing the ribs, ribbed belts enable material to be conveyed even along a steed rise;
- in contact with known air-cushion transport belts it is possible to convey materials not only of small particle size but with any particle size;
- with the transport device according to the invention (especially in the case of ribbed belts) it is possible to convey containers containing compressed gas, liquefied gas, gas liquefied by pressurization or cooling, liquids, slurries, powders etc. and these containers may be placed on the belt whilst it is moving and may be removed fom the belt whilst it is moving;

- by means of ribbed belts, long pipes and other elongated materials or members may also be conveyed if the radius of the curvature of the belt path is at least such that the longitudinal material or member should be accommodatable in it;

- the liquids and floating belts employed afford the possibility of ensuring that the power required to produce a liquid cushion should not fully expend the energy-saving due to the reduction in friction, in contrast with the case of a belt employing an air cushion;

- by utilising as the carrier medium a salt, alkali, acid, melt, an organic material of high boiling point, molten metal or other non-metallic material the construction according to the invention may also be employed in hot environments where roller-driven belts would be unsuitable.

By using the invention the area of utilisation of conveying belts is significantly enlarged. A few examples are given for this below:

The advantages of the invention show up particularly well when the transport belt is used for conveying over very large distances and very large quantities of material. In such fields it is suitable for solving problems which cannot be solved by roller-driven belts. The advantages become particularly appreciable where it is used also, or only, as a storage belt. When roller-driven belts are used as storage belts it is necessary to make the belt extremely thick but in the present case this is not necessary and also the very robust frames required for roller-driven belts are also obviated.

Transport belts can also be formed with ribbed belts according to the invention where for large distances and large dimensions the belts may be guided in purpose-built artificial channels or canals which may intermittently make use of any natural waters along the path, such as rivers, lakes or seashores. The ribbed belts enable people, particulate material and piece goods to be conveyed. In given cases, the invention may also be used for delivering to a network of shops in a city and for the automatic collection of refuse and rubbish.

Suitable ribbed belts of low profile can be used at airports and other places of high traffic density or for moving escalators or travelling stairs. The moving escalators of underground stations and stores can be simplified by utilising this invention. The construction of conveyors is also significantly simplified by using the invention.

The invention can also be used as a particularly simple means for the loading and unloading of river and sea-going ships anchored at a distance from the shore and for the removal of material from dredgers and floating production vessels employing pumps. It is also advantageous for utilisation or conveying along the shore.

The invention may advantageously be used for settling water, effluents and chemical materials by forming a counterflow movement between the liquid and the belt. Any material deposited on the belt can be removed at the end of the belt.

If a wide belt is used wih relatively little sag and a warm liquid is used as the carrier medium high efficiency can be achieved. The transport means according to the invention may also be used for coal distillation by using it in a closed space and with a melt as the carrier medium. By suitably forming the belt profile and by using carrier liquids at different temperatures it can be used as a chemical reactor or as a continuous cooking vat, depending on the area of use.

CLAIMS

1. A process for advancing a continuous band-like transport device, especially a conveyor belt, with reduced friction, the device having a load-carrying surface on its upper run or surface, wherein at least a part of the underside of the device is placed on a liquid layer and the carrier surface of the device is prevented from coming into communicating contact with the liquid layer.

2. A process according to claim 1, wherein the liquid layer is formed from liquid fed into the system under pressure.

3. A process according to claim 2, wherein the pressure of the liquid is artificially boosted.

4. A process according to claim 2, wherein the pressure of the liquid is increased by exploiting natural water level differences.

5. A process according to any preceding claim, wherein the liquid layer is formed from a liquid passed to a supporting means which is disposed beneath the device and which at least partly follows the underside of the device.

6. A process according to any preceding claim, wherein the prevention of communication between the liquid layer and the carrier surface of the transport device is effected by raising the two edges of the device relative to its central part.

7. A process according to any preceding claim where the liquid layer is formed at least in part in a liquid reservoir disposed beneath the transport device.

8. A process according to claim 7, wherein the liquid reservoir is an artificial canal.

9. A process according to claim 7, wherein the liquid reservoir is natural standing or running water.

10. Apparatus for performing the process according to claim 1 comprising a continuous band-like transport device, supporting elements for at least intermittently supporting the transport device and driving means for the transporting device wherein the transport device, expediently a belt, is supported by a supporting plate having a surface adjacent the transport device which is communicating connection with a

source of liquid via a liquid inlet duct.

11. Apparatus according to claim 10 wherein, viewed from the transport device, the supporting plate is of concave cross-section.

12. Apparatus according to claim 10 or 11, wherein the liquid duct is connected to the supporting plate in the region of the central axis of the latter.

13. Apparatus according to any of claims 10 to 12 wherein, in the direction of advance of the transport device, the supporting plate is at least intermittently provided with salients.

14. Apparatus for performing the process according to claim 1 comprising a continuous band-like transporting device, a supporting element for at least intermittently supporting the transport device and driving means for driving the transport device, wherein at least portion of the transport device is placed on a liquid layer disposed in a liquid reservoir, expediently a trough, and is of concave cross-section when viewed from above.

15. Apparatus according to claim 14, wherein the transport device is made from a material of lower mean density than that of the liquid.

16. Apparatus according to claim 15, wherein the transport device is provided with a density-reducing insert.

17. Apparatus according to any of claims 14 to 17, wherein the transport device is provided with stiffening inserts.

18. Apparatus according to claim 16, wherein at least one closed cavity is formed in the material of the transport device.

19. Apparatus according to claim 18, wherein closed cavities are provided longitudinally along the two edges of the transport device.

20. Apparatus according to claim 19, wherein protective barriers are arranged to float on the surface of the water at two sides of the transporting device and the barriers are interconnected, expediently by spacers.

21. Apparatus according to any of claims 14 to 20, wherein on its inner side opposite the liquid the transport device is provided with ribs transverse to the direction of advance.

22. Apparatus according to claim 21, wherein the transverse ribs are U-shaped.

23. Apparatus according to claim 22, wherein on the lower connecting or yoke side of the U-shaped ribs there are bores into which longitudinally extending stiffening elements, are threaded.

24. Apparatus according to claim 23, wherein the longitudinal stiffening elements have flexible elements interposed between them.

25. Apparatus according to claim 23 or 24, wherein said stiffening elements are tube pieces.

26. Apparatus according to claim 21, wherein the transport device consists of belt elements which are U-shaped members.

27. Apparatus according to claim 26, wherein said members are constituted by transversely sectioned rubber tyres which are united together at their end faces.

28. A process according to claim 1 substantially as herein described with reference to and as shown in any of Figures 1, 2, 3, 4, 5, and 6, 7 and 8, 11, 12, 13, 14, 15, 16, 17, 18 in combination with Figure 19 or 20 or 21 or 22 and 23 and 24 or 25 to 27 of the accompanying drawings.

29. Apparatus according to claim 10 or 14 substantially as herein described with reference to and as shown in any of Figures 1, 2, 3, 4, 5 and 6, 7 and 8, 11, 12, 13, 14, 15, 16, 17, 18 in combination with Figure 19 or 20 or 21 or 22 and 23 and 24 or 25 to 27 of the accompanying drawings.

New claims or amendments to claims filed on 19 April 1984
Superseded claims 1 - 29 inclusive
New or amended claims:-

1. Transporting apparatus comprising a continuous band-like transporting device capable of floating on water and made of a resilient material, driving means for advancing the transport device, one surface of the said device being adpated for carrying loads and another surface being adapted for floating immersion in water, and wherein the interior of said device, which is in use out of contact with the water, is provided with ribs extending transversly to the direction of advance of said device.

2. Apparatus according to claim 1, wherein the transverse ribs are U-shaped and follow the internal cross-section of the said transport device.

3. Apparatus according to claim 2, wherein on the lower connecting or yoke side of the U-shaped ribs there are bores into which longitudinally extending stiffening elements are threaded.

4. Apparatus according to claim 3, wherein said stiffening elements are tube pieces.

5. Apparatus according to claim 3 or 4, wherein the longitudinal stiffening elements have flexible elements interposed between them.

6. Apparatus according to claim 1, wherein the transport device is U-shaped and consists of U-section belt elements which are united at one end thereof.

7. Apparatus according to claim 6, wherein said elements are constituted by transversley sectioned rubber tyres.

8. Apparatus according to claim 1, substantially as herein described with reference to and as shown in Figures 1, 2 and 4 to 6 or Figure 3 of the accompanying drawings.

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